

SOURCE INVENTORY

CATEGORIES # 1115 - 1129

COMMERCIAL AIRCRAFT, Jet

1999 EMISSIONS

Introduction

Considered in these categories are emissions from commercial aircrafts during their operations at the three major airports in the Bay Area, namely, San Francisco International Airport, Oakland International Airport, and San Jose International Airport. A classification system for commercial aircraft was formulated consisting of major passenger, cargo, and commuter/air taxi aircraft. The major passenger aircrafts are further broken down into sub-groups of short-ranged, medium-ranged, long-ranged, and seasonal/chartered aircraft. Both the major passenger and cargo aircraft categories are primarily jet aircraft.

The basic types of gas turbine engines used for commercial (jet) aircraft propulsion are turbojet and turbofan engines:

1. In a turbojet engine, large quantities of air enter the engine in the front and then compressed and squeezed by the compressor before passing into the combustion chamber. This resulting mixture of fuel and air is then burned to produce hot, expanding gases. These high velocity gases pass through a turbine that is used to drive the compressor. The remaining energy in the air stream is used for aircraft propulsion. The earlier centrifugal type of compressor used in turbojets were reliable and simple, but the amount of thrust produced was relatively low because the compression ratio is not very high. These engines were also noisy and had poor fuel economy. Therefore, these engines were rapidly replaced by the quieter and more fuel efficient turbofan engines.
2. Turbofan aircraft engines power the majority of airline transports in service today. The air entering the forward end of the engine is compressed and then heated by burning fuel in the combustion chamber. The turbofan engine uses its fan to accelerate additional air around the outside of the engine (called the bypass flow) to produce a larger, slower-moving exhaust mass for efficient high subsonic propulsion.

The pollutants emitted by an aircraft during take-off and landing operations are dependent on the emission rates and the duration of these operations. The emission rates

are dependent upon the type of engine and its size or power rating. An aircraft operational cycle includes the landing and takeoff, or LTO cycle. An LTO cycle includes all normal operational modes performed by an aircraft between its descent from an altitude of about 2300 feet on landing and subsequent takeoff to reach the 2300-foot altitude. The 2300-foot limit is a reasonable approximation to the meteorological mixing depth over the Bay Area metropolitan areas. The term “operation” is used by the Federal Aviation Administration to describe either a landing or a take-off cycle. Therefore, two operations make one LTO cycle.

The aircraft LTO cycle is divided into five segments or operational “modes” and categorized by:

1. Landing approach (descent from about 2,300 ft. to touch down),
2. Taxi/idle-in,
3. Taxi/idle-out,
4. Take-off,
5. Climb out (ascent from lift-off to about 2,300 ft.).

The emissions are based on the time of operation in each mode and the emission rates of the engines. The time in the landing approach and climbout modes are assumed to be 3.02 minutes and 1.55 minutes, respectively. Take-off time of 0.95 minute is fairly standard for commercial aircraft and represents the time for initial climb from ground level to about 500 feet. The time in taxi/idle mode usually varies with airports. For congested airports, the taxi/idle time can be as much as three to four times longer than as in uncongested airports. Typical duration for civil aircraft LTO cycles at large metropolitan areas are shown in EPA document AP-42, Table II-1-3.

There are many types of aircraft in use today. Only the commonly used commercial aircraft are considered in these categories.

Methodology

The number of operations and fleet mix were obtained from the three major commercial airports in the Bay Area and the Metropolitan Traffic Commission (MTC). Emission rates vary according to engine type and operating mode. Modal emission rates for aircraft engine now in general commercial use were obtained from AP-42, Table II-1-7 and the FAA Aircraft Engine Emission Database (version 2.5). Emission factors for a specific aircraft were estimated by the equation:

$$EMF = N \sum (v_e/v_t)_{m,p} \times TIM$$

where EMF = Emission Factor, with units in lbs./LTO

N = number of engines,

$(v_e/v_t)_{m,p}$ = engine emission rates, lbs/hr at mode m, pollutant p, and

TIM = time in mode, hr.

Sample calculations (Cat. No. 1117):

Data: 4,878 LTO/yr.,

For B747-300 (long-ranged aircraft at SFO)

TOG emission factor = 61.05 lbs./LTO

$$\begin{aligned} \text{Emission} &= 4,878 \text{ LTO/yr.} \times 61.05 \text{ lbs./LTO} / 365 \text{ days/yr} / 2000 \text{ lbs./ton} \\ &= 0.41 \text{ ton/day of organics} \end{aligned}$$

Monthly Variation

Monthly distribution was based on the monthly number of operations at each airport.

County Distribution

The county location of each airport was used to distribute emissions into each county, where SFO is in San Mateo County, OAK is in Alameda County, and SJC in Santa Clara County.

TRENDS

History

Emissions through the years were estimated based on the above methodology, and the actual number of operations from each airport. Selected years were calculated with corresponding estimates of the aircraft fleet mix during those times.

Growth

The continuing effort in aircraft improvement, development of newer engine technology and their phasing in will result in reduced emissions. Airport noise regulations are forcing changes to the commercial aircraft fleet resulting in replacement of loud and dirty engines with newer, quieter, and cleaner burning engines. There is a continuing trend in

the use of larger aircraft thereby increasing the passenger to LTO ratio. This will reduce the number of LTOs and consequently, lower emissions.

It is difficult to project what will be the future mix of aircraft at each airport. The airline fleet modernization occurs continually and varies according to travel demand forecasts, changes in marketing strategy, cost of capital, and the financial situation of the individual airlines.

The projections for number of operations and fleet mix at each airport were developed from the airport data and the MTC's 1994 and 2000 Regional Airport System Plan (RASP). Emissions for selected years (1999, 2010 and 2020) were calculated based on the above methodology. Emission values for other years were obtained by interpolation.